CLAIMS:

Having thus described our invention, what we claim as new and desire to secure by Letters Patent is as follows:

1. A method for forming a tantalum nitride layer on a substrate, the method comprising:

depositing the layer on the substrate by plasma enhanced atomic layer deposition of a tantalum halide precursor in the presence of a hydrogen plasma and a nitrogen plasma.

2. The method as recited in claim 1, further comprising varying concentration of nitrogen plasma to thereby vary the amount of nitrogen in the layer.

3. The method as recited in claim 2, wherein the concentration of nitrogen plasma is varied so that the layer has a nitrogen to tantalum concentration ratio of between 0 and 1.7.

4. The method as recited in claim 1, further comprising reducing concentration of nitrogen plasma to zero so that a substantially nitrogen free layer of tantalum is formed.

5. The method as recited in claim 4, wherein the concentration of nitrogen is other than zero for a first period of time, and the concentration of nitrogen

plasma is essentially zero for a second period of time, so that a first layer of tantalum nitride is formed and a second layer of substantially nitrogen free tantalum is formed.

6. The method as recited in claim 5, wherein the combination of the first layer and the second layer is used as a diffusion barrier for copper.

7. The method as recited in claim 5, wherein said second layer is deposited upon said first layer.

8. The method as recited in claim 1, wherein temperature of the substrate is between 100 °C and 450 °C.

9. The method as recited in claim 1, wherein temperature of the substrate is 300 °C.

10. The method as recited in claim 1, wherein the layer is used as a diffusion barrier for copper.

11. The method as recited in claim 1, wherein the layer is deposited on a substrate selected from the group consisting of silicon, silicon having a layer of silicon dioxide on the silicon, a low dielectric constant substrate, and a porous low dielectric constant substrate.

12. A method as recited in claim 11, wherein the substrate is a low dielectric constant substrate and has a dielectric constant in the range of 2.0-3.0.

13. A method as recited in claim 11, wherein the substrate has copper conductors, and the layer serves as a diffusion barrier for said copper.

14. A method as recited in claim 1, wherein the tantalum halide is tantalum pentachloride.

15. A method as recited in claim 1, wherein the depositing comprises:

a. exposing the substrate to the tantalum halide carried by an inert gas;

b. exposing the substrate to the hydrogen and nitrogen plasma; and

c repeating a. and b. until a desired thickness of the layer is obtained.

16. A method as recited in claim 15, wherein the exposing the of the substrate to the tantalum halide carried by the inert gas is performed at a pressure of 3.0×10^{-2} Torr.

17. A method as recited in claim 15, wherein during the exposing of the substrate to the hydrogen and nitrogen plasma, partial pressure of hydrogen is 2.5×10^{-2} Torr.

18. A method as recited in claim 15, wherein a. and b. are repeated approximately 40 - 800 times.

19. A method as recited in claim 15, wherein the exposing of the substrate to the tantalum halide carried by the inert gas is carried out for approximately 2 seconds; and the exposing of the substrate to the hydrogen and nitrogen plasmas is carried out for approximately 5 seconds.

20. The method as recited in claim 1, wherein the substrate is simultaneously exposed to the nitrogen plasma and the hydrogen plasma.

21. The method as recited in claim 1, wherein the substrate is sequentially exposed to the nitrogen plasma and the hydrogen plasma.

22. An article of manufacture comprising:

a substrate;

a bilayer of tantalum nitride and tantalum on said substrate, each of said tantalum nitride and said tantalum being substantially free of carbon.

23. An article of manufacture as recited in claim 22, wherein the tantalum layer comprises amorphous tantalum.

24. An article of manufacture as recited in claim 22, wherein said tantalum is disposed on said tantalum nitride.

25. An article of manufacture as recited in claim 22, wherein the carbon content is below five percent.